ISCR-Enhanced Bioremediation Accelerates Groundwater Cleanup at Active Manufacturing Facility

In the winter of 2008, full-scale in situ chemical reduction (ISCR) was implemented as a removal action at the Siltronic Corporation site in Portland, OR, to treat a source area contaminated by releases of TCE. The source area was considered to be the portion of the site with concentrations of TCE in groundwater greater than 11,000 µg/L, suggesting the presence of TCE as DNAPL. Implementation involved injecting a controlled-release, integrated carbon and micro-scale zero valent iron (ZVI) reagent (EHC™) and selected microbial agents (KB-1™) throughout approximately one-half acre of the source area accessible to drilling equipment. The approach was selected following a comparative bench testing along with other alternatives, and a successful field pilot of combined EHC+KB-1 injections. ISCR enhanced bioremediation was selected due to its: (1) lower cost when compared to alternate but resource-intensive technologies such as electrical resistance heating (ERH); (2) higher predictability than technologies such as surfactant flushing or emulsified oil sequestration; and (3) compatibility with ongoing manufacturing operations and facilities. The groundwater RAO set by the Oregon Department of Environmental Quality (ODEQ) for the source area was achieved in less than six months after completion of the injection, and TCE concentrations decreased to below the MCL in several onsite locations.

Silicon wafers have been manufactured at the 80-acre Siltronic site since 1980. Solvent releases during the early 1980s created a CVOC source area and downgradient plume approximately 1,100 feet long and greater than 500 feet wide; a portion of the plume extends under and discharges into the Willamette River. In 2006 site investigations, TCE was identified in source area groundwater at concentrations reaching 592,000 µg/L, suggesting the presence of DNAPL. Investigations also indicated a roughly half-acre TCE source area extending approximately 40-110 feet bgs and located approximately 500 feet upgradient of the riverbank. ODEQ established a groundwater RAO for the removal action of reducing dissolved-phase TCE concentrations to less than 11,000 µg/L (i.e., 1% of the TCE solubility limit) in source zone wells.

Siltronic evaluated cleanup options given the limited space to operate and proposed a controlled-release mixture of carbon and ZVI that yields redox potentials favorable for the biological reductive dechlorination of contaminants. Although the presence of 1,2-DCE, vinyl chloride (VC), ethene, and ethane in downgradient groundwater indicated natural biodegradation was occurring, Siltronic proposed augmenting the source area's microbial populations with TCE-targeting microbes and stimulating existing populations with an additional carbon source. The combined effect of the carbon, ZVI, and augmentation was expected to increase microbial activity and reduce dissolved phase TCE concentrations through abiotic and biotic degradation. In addition, enhanced in situ bioremediation was expected to increase concentration gradients near DNAPL, thus facilitating more rapid chemical dissolution and treatment once contaminants were in the dissolved phase.

Starting in January 2009, a 30% carbon and ZVI slurry was injected to 40-112 feet bgs using a direct push (DP) drill rig. The slurry was injected on the downward push of the rig's tailored injection head to target 4-foot vertical intervals among injection point lines at 7-foot spacing. The microbe culture was emplaced 7-14 days later in the same holes through use of a peristaltic pump and a standard DP well screen from the bottom-up. This injection process continued for six months with approximately 200 overlapping injection points advanced within accessible portions of the source area. Based on the volumes used in an earlier pilot-scale test, approximately 594,000 pounds of the carbon and ZVI fine powder and 1,831 liters of microbe culture were injected into the subsurface. Groundwater was monitored at 23 wells located within and upgradient of the treatment area, with 13 of the wells indicating TCE above 11,000 µg/L in the pre-injection sampling event. Through December 2009, TCE concentrations in all 13 of these wells had decreased to levels lower than the 11,000 µg/L goal. By April 2010, TCE concentrations had been reduced to less than 100 µg/L at 12 of the 13 wells, and by August 2010 to less than the 5 µg/L MCL in seven of the wells.

Groundwater monitoring will continue within and downgradient of the source area to demonstrate the observed TCE reductions are sustainable and to monitor potential rebound. Contaminant rebound is considered a reasonable scenario as the source area is underlain by unconsolidated fine-grained sediments, which could represent contaminant reservoirs and because DNAPL was likely present in the source area. Future monitoring will also be used to assess the effectiveness of ISCR at treating CVOCs (e.g., 1,2-DCE, and VC) produced in the source area through TCE dechlorination.

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